Vol. III, No. 29. Washington, D. C. Dec. 7, 1883.

107.—NOTES ON THE MODEL OF THE GULF OF MAINE CONSTRUCTED FOR THE UNITED STATES FISH COMMISSION.

By A. LINDENKOHL.

MODEL MADE FOR THE FISH COMMISSION.—A model of the Gulf of Maine was constructed for the United States Fish Commission, in order to exhibit clearly the geological construction of this part of the Atlantic; this construction being of such an intricate nature that it cannot be discerned with the distinctness and minuteness desirable from hydrographic charts.

Such charts, in general, are not the best medium to convey exact conceptions of shapes of bottom for the reason that figures are employed to denote depths instead of contour lines, and also for the more important reason that there will always exist anomalies and deficiencies upon such charts owing to imperfect methods of surveying.

If soundings would furnish us a correct idea of the bottom, the production of a faithful model would be a mere question of mechanical skill; but it is a matter of fact that whenever there is great irregularity in the form of the bottom soundings only furnish indications of its shape, and it requires considerable geological knowledge and familiarity with the various molds employed by nature under given circumstances in order to obtain an intelligible representation of the bottom.

Holding these views, I think it incumbent upon me to submit a resumé of the results arrived at whilst engaged upon the model of the Gulf of Maine, in order that those who are able to judge may determine to what extent nature has been properly interpreted.

BOUNDARIES OF THE GULF OF MAINE.—The term "Gulf of Maine" was first employed by the United States Coast Survey to designate that part of the Atlantic which lies between the eastern coast of the New England States and Nova Scotia, to the northward of a line from Nantucket to Cape Sable, and which connects with the Bay of Fundy towards the northeast.

NANTUCKET SHOALS.—The Nantucket Shoals comprise a series of narrow bands of shoal ground off the island of Nantucket, reaching out in a southeast direction about forty miles. Besides ascertaining their positions, the Coast Survey has developed the fact that the shape of the shoals conforms in a remarkable degree to the directions of the tidal currents. The flood current sets in from the southwest and the ebb current from the northeast, both moving over the same ground in reversed directions, which coincide with the major axes of the shoals.

Tidal currents have not only given shape to the shoals but have also abraded the island to a considerable extent. Nantucket Island consists of sand and other drift material loosely piled up; consequently the

highest elevation should be found about the middle of the island. In fact, however, this elevation, about 100 feet, is found at Sankaty Head, its most projecting point, and hence we conclude that in former times the island has extended over a part of the ground now occupied by the shoals. The southern coast of the island, that west of Sankaty Head, has received its shape from the flood current, whilst the west coast, or that north of Sankaty Head, has been formed by the ebb current.

GEORGE'S BANK.—The existence of this bank must have been known to the earliest navigators; it was originally called Malebarre Bank, but has borne its present name since about 1700. The total absence of cretaceous and tertiary deposits from the eastern coast of Massachusetts and the coast of New Hampshire leads Professor Hitchcock to the conclusion that during those ages these coasts must have occupied a higher level than at present; hence it is possible that a greater or lesser part of George's Shoal may once have been dry land. However that might have been, there is not the least doubt from an examination of the surface deposit that the bank owes its present shape and height to a thick layer of drift material belonging to the glacial period. Indeed, it is not possible to suppose that masses of ice, many thousands of feet in height, would have finally melted before coming into contact with the warm waters of the Gulf Stream off the southern edge of George's Bank. Hence we may consider this bank as the terminal moraine of the glaciers belonging to the glacial period and subsequent to it. Between this bank and the coast of Maine there exists a relation very similar to that between the southern and northern shores of the Great Lakes, and it would require an elevation of less than 1,000 feet to convert the Gulf of Maine into an inland sea.

The shoalest parts of this bank, George's Shoal and Cultivator Shoal, have less than three fathoms and must be considered dangerous to navigation. From the fact that these shoals conform in their directions to the tidal currents which run across the bank at nearly a right angle to its general stretch, and maintain their shape and position in spite of their exposed location, we are justified in considering them as the permanent result of tidal action.

CAPE COD.—Cape Cod is an immense heap of drift material. Its topographical configuration alone shows that, like Nantucket, it has received great abrasion on its eastern side. The greatest height, about 200 feet, exists at the Highlands—the most exposed position, where there has been the greatest wear. The tidal currents, which in this abrasion process we must consider the most persistent if not the most active, run parallel to the coast, the flood from the south and the ebb from the north.

STILLWAGEN'S BANK.—This shoal, discovered by the Coast Survey in 1854, lies across the entrance of Massachusetts Bay in a line from Cape Cod to Cape Ann. There is very little doubt in my mind that this bank belongs to the same geological formation as Cape Cod; that it formerly was probably much shoaler and directly continuous to Cape

Cod. It cannot be assumed to be a fold of strata on the Appalachian system, because these strata have a southwest and northeast direction. A look at the map of Cape Cod shows that this coast is subjected to the visitations of powerful northwest and northeast winds, which roll up sand dunes a hundred feet high. If we furthermore mention the circumstance that the tidal currents which run into and out of Massachusetts Bay make right across the bank, we have named two agents which work at its destruction. Its existence in its present shape and depth of about 10 fathoms as a submarine bank is largely due to the protection afforded by Cape Ann and Jeffrey's Ledge on the northward and by Cape Cod on the southward.

THE MASSACHUSETTS COAST.—The coast of Massachusetts assumes a distinctly rocky appearance about Scituate and maintains this character to beyond Cape Ann. According to Professor Hitchcock (Smiths Cont., Vol. IX), Boston Harbor has been scooped out of softer metamorphic slates by the action of tides and breakers, whilst these agents had no perceptible influence upon the unyielding syenite of Cape Ann and Cohasset.

JEFFREY'S LEDGE.—Jeffrey's Ledge, off the coast of New Hampshire, lies in direct continuation of Cape Ann, and extends in a direction parallel to the ranges of hills composing the cape. This ledge presents a very different appearance from the banks heretofore considered; it is much bolder, and instead of a large and nearly level surface, as possessed by George's Bank and Stillwagen's Bank, it shows a narrow ridge, rapidly falling off east and west into depths of over one hundred fathoms. This shape points to subterranean upheaval as the cause of its formation, and we conclude that it is the continuation of Cape Ann and identical with it in its geological structure; that its body consists of granite and syenite. The difference in level, Cape Ann being about 250 feet above and the ledge 90 feet below the ocean, is inconsiderable in a geological view. It is a characteristic feature of this one and nearly all the other ledges in the Gulf of Maine that their surface is covered by a fine sand, which changes into a coarser sand and gravel on their sides, which in turn are lost under a thick covering of mud when we get into the deeper parts of the gulf.

THE NEW HAMPSHIRE COAST.—Between Cape Ann and Hampton River we meet alluvial deposits, but thence to beyond the limits of New Hampshire, to Cape Small, in Maine, we find stratified rocks, which may be designated as metamorphic slates (principally mica schist) with numerous irruptions of granite and trap. Cape Elizabeth and the islands in Casco Bay belong to this formation. According to the soundings it extends a considerable distance into the sea and includes the Isles of Shoals, Boon Island, and the ledges off Portland Harbor. The strike of the strata is uniformly northeast, and the peculiar tendency of this region is the formation of low and parallel ridges of hills and islands above the water and of submarine rocky ledges running northeast. Cape Eliza-

beth rises to about 150 feet, and at about an equal depth, 25 fathoms, the traces of this formation are lost in the ocean.

THE COAST OF MAINE.—From Portland to Eastport the coast of Maine has that characteristic appearance which we only find in the coast line of high latitudes on both continents, which we attribute to attrition by ice and call the *fiord* formation. Fiords are essentially a succession of narrow channels, seldom exceeding one or two miles in width, with parallel sides and running in approximately parallel directions. These channels are generally separated by equally narrow peninsulas or ranges of islands. The inclination to parallelism is, in general, sufficiently pronounced to enable us to detect these regions by a mere inspection of the charts.

Assuming with Professor Dana, and the late Prof. Louis Agassiz, that these fiords have been excavated above the level of the sea by the grinding action of bases of glaciers, we find that the coast of Maine must have stood about 50 fathoms above its present level when its fiords were being shaped, since they extend to about that depth below the present level of the sea. In many places we find this depth exceeded, notably in the case of important channels. In the channel of Penobscot Bay we have depths of 83 fathoms; but we can account for these contradictions without casting loose from the glacier theory by making allowance for the weight of a glacier making itself felt to some distance into the sea and by assuming the occurrence of gorges in the defiles of long channels.

In studying the effects of glacial action upon the configuration of the coast of Maine we have to draw a distinction between the movements of large continuous masses of ice in a uniform direction independent of the shape of the ground and the motion of local glaciers dependent upon the shape of the ground. To the former we must ascribe the striæ in the rocks about Portland and elsewhere, the general shape of the islands off the coast and of the hills and mountains along the coast, and also the more important river channels. Most probably there was a gradual transition from the great "continental glacier" to local glaciers, and the work commenced by the former received its finishing touches by the latter.

The prevailing directions of the striæ and fiords on the coast of Maine are south and south-southeast. Portland Harbor is a fiord channel, cut out of the slate strata of Cape Elizabeth, at an angle of about 60° to the strike of the rocks. East of the White Mountains, ranging in height from 4,500 to 6,300 feet, the most conspicuous elevations on the coast are the Camden Hills, about 1,300 feet high, and Mount Desert Island, 1,532 feet. Midway between the Camden Hills and Mount Desert we have Isle au Haut, 556 feet high. These hills must have offered considerable resistance to the ice coming from the northward, and hence we find the strongest traces of glacial action in the vicinity of Penobscot Bay and Mount Desert Island.

MOUNT DESERT ROCK.—This rock occupies the most isolated and

most exposed position of any island on the coast of Maine. Its preservation through the glacial period must be ascribed partly to the hardness of its mineral composition, and partly to its position in the rear of Mount Desert Island, with which it is connected by a ridge, at a depth of about 80 fathoms.

GRAND MANAN ISLAND.—This island, which rises to the height of about 400 feet, lies in the middle of the entrance to the Bay of Fundy. It belongs, politically, to the Province of New Brunswick, but, in its topographical and geological structure, it resembles more closely Maine, from which it is separated by a channel of rather less than 40 fathoms. It even appears probable that, during the earlier parts of the glacial period, this island formed a part of the coast of Maine.

CASHE'S LEDGE.—Cashe's Ledge is a rock with 5 fathoms of water on it. Situated near the middle of the gulf, it constitutes the only danger in the deeper waters of the gulf, and inside of George's Bank. Cashe's Ledge and Ammen's Rock are identical, although two rocks are indicated on the Coast Survey charts. This doubling a single rock is owing to uncertainty of position, and is in accordance with the maxim that it is safer, in cases of doubt, to give one more rock than really exists, rather than omit one. Cashe's Ledge forms the crest of the middle one of three submarine ridges, which probably consist of granite and show, by their shapes, that they have been subjected to strong glacial abrasion. It is not improbable that these rocks may have been above water in antediluvial times.

PLATT'S BANK.—The existence of this bank was known to fishermen before its discovery and survey by Captain Platt, of the Coast Survey It is situated upon the same rocky plateau with Cashe's Ledge, Jeffrey's Bank, and the Fippennies. It has 29 fathoms' depth, whilst Jeffrey's Bank and the Fippennies, the existence of which has been generally known much longer, have a depth of 46 and 39 fathoms, respectively. None of these ledges have much importance, either to navigation or as fishing grounds, and their shapes have not been as well determined, by survey, as the ledges previously mentioned. Hence we will not venture upon any hypothesis regarding their geological structure, beyond the statement that they must be composed of some hard material, since they occupy positions where they must have been subjected to strong glacial abrasion.

GULF OF MAINE—GENERAL DISCUSSION.—We may fairly assume the whole of the Gulf of Maine, from the foot of the fiords to George's Bank, to be strewed over with bowlders, and the *débris* of melted glaciers and icebergs; but all this, in the deeper parts of the gulf, is hidden under a heavy layer of mud. The greatest depth in the gulf is about 180 fathoms, and this depth is reached in both basins, the one to the eastward and the one to the westward of Cashe's Ledge. This depth is rather insignificant, when compared with the depths outside of the banks, where, at a distance of only 20 miles, 1,500 fathoms are rached.

The main part of the gulf has a flat bottom, ranging in depth from about 90 to 180 fathoms. In its shoaler parts, at a depth of about 100 fathoms, there are indications of flat ridges, which attach themselves to rocks and ledges, and stretch in the direction of prevailing currents.

At a depth of 40 fathoms George's Bank is united with Nantucket Shoals, and this vast bank, which lies across the entrance to the gulf, is almost continuous to Sable Island Bank. The separating channel is only about 140 fathoms deep and 20 miles wide; at a depth of 500 fathoms every trace of it disappears.

The existence of elevated sea beaches, around the Gulf of Maine, goes to prove that, at a time subsequent to the glacial period, when the river valleys in New England were filled with water to their very tops, at the time of the "Champlain Period," the shores of the gulf had subsided, at Sankaty Head, 85 feet; at the coast of Maine, in some parts, 217 feet; about the Bay of Fundy, 350 to 400 feet (Dana's Manual of Geology). In consequence of this subsidence, the waters of the Saint Lawrence must have had free access to the Gulf of Maine, since the separating isthmus is only about 20 feet above high water. Great quantities of floating ice must have passed through the Bay of Fundy, and the steepness of the banks of the channels, on both sides of Grand Manan Island, bears evidence of powerful abrasion from the direction of the Bay of Fundy.

The effect of a boreal current upon the fauna and upon the climate of the Gulf of Maine is a very tempting subject for inquiry, but it is beyond the scope of the present article.

In Passamaquoddy Bay, about Eastport, we find very marked fiord indications running southeast, and again, others nearly as well developed, bearing west of south. According to the views heretofore expressed, the first are contemporary in formation with similar marks found along the whole coast, and belong to the earlier part of the glacial period, whilst the southwest marks belong to a later part and are of a more local character.

WASHINGTON, D. C., *December* 26, 1882.

108.—REPORT UPON HATCHING ONE MILLION WHITEFISH EGGS FROM THE GREAT LAKES AT ORLAND, ME., AND UPON PLANTING THE YOUNG IN EAGLE LAKE, MOUNT DESERT.

By H. H. BUCK.

The eggs came on Monday, February 26, in one case, which was large and heavy and not provided with handles, so that it was rather weak when it arrived. The eggs were immediately taken out and found to be cool. The temperature of the moss was below 35°, but a small per-